REMARKS

STATUS OF THE CLAIMS

Claims 1, 3, 6-8, 10-12, and 14-22 remain in the application. Claims 1, 3, 6, 7, and 8 have been amended. Claims 2, 5, and 9 have been canceled. New Claims 23-31 have been added. Claims 10-12, 14-20, and 22 are allowed.

The Office rejected Claims 1-3, 5, and 8 under 35 U.S.C. 103(a) as being unpatentable over *Vogt*.

The Office rejected Claims 6, 7, and 9 under 35 U.S.C. 103(a) as being unpatentable over *Vogt* and further in view of *Andrew*.

The Office rejected Claim 21 under 35 U.S.C. 103(a) as being unpatentable over *Vogt* and further in view of *Kotula*.

SUMMARY OF THE INVENTION

The present invention is directed to a method for spatially compressing data sets enables the efficient analysis of very large multivariate images. The spatial compression algorithms use a wavelet transformation to map an image into a compressed image containing a smaller number of pixels that retain the original image's information content. Image analysis can then be performed on a compressed data matrix consisting of a reduced number of significant wavelet coefficients. Furthermore, a block algorithm can be used for performing common operations more efficiently. The spatial compression algorithms can be combined with spectral compression algorithms to provide further computational efficiencies.

SUMMARY OF THE ART

Vogt and *Tacke*, Chemometrics and Intelligent Laboratory Systems 59, 1 (2001), discloses algorithms for the fast PCA analysis of large data sets. The acceleration of the PCA is achieved by wavelet data compression of the spectra before calculating the SVD in the wavelet domain. The wavelet coefficients of the transformed matrix are thresholded to eliminate noise. The inverse transform results in denoised principal

components that retain the relevant spectral features. The PCA in the disclosed examples could be accelerated up to a factor of 52.

Andrew and *Hancewicz*, Appl. Spectroscopy 52(6), 797 (1998), discloses the application of two-way curve resolution methods, including principal factor multivariate curve resolution (PF-MCR) and orthogonal projection multivariate curve resolution (OP-MCR), to analyze three-way Raman image data. A 3-way array is reorganized into a two-way m x n data matrix D. PF-MCR uses a principal factor analysis (PFA) to decompose the data matrix D into submatrices C and S of abstract intensity and spectral factors, respectively. MCR is then performed on the abstract factors. A vector rotation can be applied to the abstract factors to emphasize the basic underlying structure of the data while keeping the vectors orthogonal. Alternating least squares (ALS) is then performed on the rotated abstract factors to produce optimized intensity and spectral profiles that reflect those of the real components in the data.

Kotula et al., "Automated analysis of SEM X-ray spectrum images: A powerful new microanalysis tool," Microscopy and Microanalysis 9, 1 (1997), discloses a weighted data matrix.

ARGUMENTS

CLAIMS 1, 3, AND 8, LIMITED TO SPATIAL COMPRESSION OF A SPECTRAL DATA MATRIX, ARE NOT OBVIOUS UNDER 35 U.S.C. § 103(a) AS BEING UNPATENTABLE OVER *VOGT*.

The Office rejected claims 1-3, 5, and 8, asserting that the Applicant's spatial compression method is made obvious by *Vogt's* spectral compression method. To establish a *prima facie* case of obviousness, the prior art must teach or suggest all the claim limitations, there must be some suggestion or motivation to modify or combine the reference teachings, and there must be some reasonable expectation of success. *See* MPEP 2143.

Applicant has canceled claims 2 and 5. Applicant has amended claims 1, 3, and 8 to more clearly recite the method 50 of the present invention described on page 38, line 18, through page 41, line 18; and pages 45-46; and shown in FIGS. 11 and 12. In particular,

steps 1a) and 1b) of amended claim 1 are described on page 39, line 6, through page 40, line 13, and shown in FIG. 11. Steps 1c) and 1d) are described on page 41, lines 9-18, and page 46 and are shown in FIG. 12. The amendment to claim 3 is described on page 39, wherein Haar transforms are applied independently to the rows and columns of the two-dimensional data matrix (i.e., the Haar transform is implemented as an orthogonal matrix and applied channel-wise to an *m*-row x *n*-column x *p*-channel data set $\underline{\mathbf{D}}$). The amendment to claim 8 is described at page 46, lines 3-24, and shown in FIG. 12.

The prior art must teach or suggest all of the claim limitations. *Vogt* works on a data set that is reduced in the spectral dimension. The Office states that "While Vogt *et al.* discloses compressing loading matrix S for the benefit of faster computation and reduced data, it does not explicitly disclose compressing C (matrix $\mathbf{U} \cdot \mathbf{S}$ in Vogt, equations 1 & 2) using wavelet transform followed by taking the inverse transform of the compressed matrix." As observed by the Office, *Vogt* only describes wavelet transformation of the matrix $\mathbf{V}^T$ of the matrix $\mathbf{M}_{(kxn)} = \mathbf{U}_{(kxk)} \cdot \mathbf{S}_{(kxk)} \cdot \mathbf{V}^T_{(kxn)}$, where $\mathbf{V}^T$ represents the calibration spectra and $\mathbf{U} \cdot \mathbf{S}$ represents the component concentrations. *Vogt* applies a one-dimensional (1D) wavelet transform to the spectra of $\mathbf{V}^T$ and the transformed spectral matrix is thresholded to eliminate noise. Thresholding the principal components (i.e., the rows of the spectral matrix $\mathbf{V}^T$) provides a shrunken matrix $\tilde{\mathbf{M}}_{\neq 0} = \mathbf{U}_{(kxk)} \cdot \mathbf{S}_{(kxk)} \cdot \tilde{\mathbf{V}}^T_{\neq 0}$. Therefore, the inverse transform results in denoised principal components. *See Vogt*, 1. Introduction; and 2. Theory.

If applied to the spatial domain, *Vogt's* method would necessarily throw away all of the spatial detail when performing the inverse wavelet transform. Conversely, Applicant teaches, and claims 1, 3, 6-8, 21, and 23-25 and new claims 26-31 recite, two different methods to retain that detail. This is a very important distinction if those details convey real chemical information rather than simply noise. A case in point is FIG. 13C, which, within a scale factor (256, the compression factor), would be the result that *Vogt's* method would provide. Conversely, Applicant's methods give the result shown in FIG. 13D. *See* Application, page 48, lines 16-23. Obviously, FIG. 13D is a much higher fidelity representation of the fine structure of the sample's composition.

Mathematically, in the physical domain of real spectra, there are m x n wavelet coefficients at each spectral channel, where m x n is the total number of pixels (i.e., spectra). In the component domain, however, there are only q coefficients at each channel, where q is the number of components. In other words, in order to retain the detail, a method is needed that transforms a large number of wavelet coefficients in the physical domain into a small number of wavelet coefficients in the component domain prior to doing the inverse wavelet transform. Applicant teaches this method in Eq. 64, for example. *See* Application, page 43, line 18, through page 44, line 1. *Vogt's* method corresponds to the very special case of setting $\tilde{\mathbf{D}}_d$ to zero in Eq. 64, i.e., throwing away all of the detail. This is shown in *Vogt's* Fig. 1 and surrounding discussion. *See Vogt*, pages 3-4. *Vogt* states on page 3, col. 1, lines 5-8, "For further mathematical operations, zeros are introduced into these shrunken PCs at that wavelet indices, at which, noise wavelet coefficients were canceled before. Thus, the inverse transformation results in denoised PCs of original length in the wavelength domain." Applicant teaches how to introduce transformed detail coefficients rather than simply zeros into these wavelet indices, thus allowing Applicant to retain the spatial detail which, as noted above, describe not noise (as assumed by *Vogt*) but real structural information about a sample.

Further, obviousness can only be established by combining or modifying teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge generally available to one of ordinary skill in the art. *See* MPEP 2143.01. The burden is on the Office to explain why the combination of the teachings is proper. The Office merely makes the conclusory statement that "It would have been obvious at the time the invention was made to one of ordinary skill in the art to apply Vogt's technique ...to the case where matrix $\mathbf{U} \cdot \mathbf{S}$ is now compress followed by taking the inverse wavelet transform of the compressed $\mathbf{U} \cdot \mathbf{S}$ matrix for the purpose of efficiently analyzing scores matrix by removing the redundant elements of the matrix". *See* Office Action, page 4. The Office does not articulate a reason why Applicant's spatial compression method would be obvious to try or that such a method would lead to predictable results. *See* MPEP 2145.X.

Conversely, Applicant teaches, and claims 1, 3, and 8 recite, methods for spatial compression of a data matrix. That is, Applicant works on a data set that is reduced in spatial dimensions. Since the spatial information is two spatial dimensions, spatial compression applies a 2D wavelet transform to the data matrix to provide a 2D transformed data matrix. *See* Application, page 39, lines 6-20. This compression provides a reduced number of spatial pixels, but with a full spectrum at each of the compressed pixels. Such spatial compression is not obvious to try, nor is it a simple substitution of the compression of one factor for another with predictable results, as implied by the Office. The method and advantages of spatial compression were first recognized and demonstrated by Applicant.

Additionally, *Vogt* only uses a single level of wavelet transformation and does not teach or suggest a multiresolution approach. Applicant can recursively apply wavelet transforms to the approximation coefficients to achieve very high compression levels comprising multiple levels of approximation subimages. *See* Application, page 38, lines 4-17; page 45, lines13-23; and FIG. 11. The usefulness of the multiple level decompositions is shown in Fig. 14, which demonstrates the higher sensitivity that can be achieved with 5 levels of compression. *See* Application, page 49, lines 1-15.

Finally, there must be some reasonable expectation of success. Spatial compression has several advantages that are not obvious and cannot be realized in spectral compression, as taught by *Vogt*. Due to the high degree of redundancy in spatial images, much higher compression levels can generally be achieved. *See* Application, page 36, line 24, through page 37, line 5. Additionally, spatial compression enables improved sensitivity to the pure spectral components and improved signal-to-noise. *See* Application, page 48, line 24, through page 49, line 15; and FIG. 14. Finally, because a 2D wavelet transform is applied, the rows and columns can be treated separately and a spatial filter can be matched to the spatial characteristics of the sample. Such asymmetric filtering can improve sensitivity to certain features. *See* Application, page 49, lines 16-30, and FIG. 49.

Applicant submits that the Office has not established a *prima facie* case of obviousness. Accordingly, Applicant submits that this rejection is overcome and that amended claim 1

is in condition for allowance. Furthermore, Applicant submits that claims 3 and 8, which depend from and further define claim 1, are likewise in condition for allowance. *See* MPEP 2143.03.

CLAIMS 6, 7, AND 9

The Office rejected claims 6, 7, and 9 under 35 USC 103(a) as being unpatentable over *Vogt* in view of *Andrew*. Applicant has canceled claim 9. Applicant has amended claims 6 and 7 to more clearly recite the method 50 of the present invention. The amendment to claim 6 is described on page 41, lines 9-18. The amendment to claim 7 is described at page 41, lines 16-18. Applicant has argued, *supra*, that claim 1 is in condition for allowance. Accordingly, Applicant submits that claims 6 and 7, which depend from and further define claim 1, are likewise in condition for allowance. *See* MPEP 2143.03.

CLAIM 21

The Office rejected claim 21 under 35 USC 103(a) as being unpatentable over *Vogt* in view of *Kotula*. Applicant has argued, *supra*, that claim 1 is in condition for allowance. Accordingly, Applicant submits that claim 21, which depends from and further defines claim 1, is likewise in condition for allowance. *See* MPEP 2143.03.

NEW CLAIMS 23-25

Applicant has added new claims 23-25 to more clearly recite the method 50 of the present invention described on page 38, line 18, through page 41, line 18; and pages 45-46; and shown in FIGS. 11 and 12. New claims 23 -25 describe in greater detail how the above steps 1b) and 1d) are actually executed on a computer. Applicant has argued, *supra*, that claim 1 is in condition for allowance. Accordingly, Applicant submits that claims 23-25, which depend from and further define claim 1, are likewise in condition for allowance. *See* MPEP 2143.03.

NEW CLAIMS 26-31

Applicant has added new claims 26-31 to more clearly recite the method 60 of the present invention described on page 38, line 18, through page 41, lines 9-18; pages 45 and 47; and shown in FIGS. 11 and 12. In particular, steps 26a) and 26b) of claim 26 are

described on page 39, line 6, through page 40, line 13, and shown in FIG. 11. Steps 26c) and 26d) are described on page 41, lines 9-18, and page 47 and are shown in FIG. 12. Claim 27 is described on page 39. Claim 28 is described on page 41, lines 9-18. Claim 29 is described at page 41, lines 16-18. Claim 30 is described at page 46, lines 25-27. New claims 31 describes in greater detail how the above step 26b) is actually executed on a computer.

REQUEST FOR CONTINUED EXAMINATION UNDER 37 C.F.R. §1.114

Applicants have submitted herewith a Request for Continued Examination. Please charge $810 for the RCE and any additional fees that may be required to Deposit Account No. 19-0131.

CONCLUSION

Applicant has responded to each and every requirement and urges that the claims as presented are now in condition for allowance. Applicant has responded within two months of the mailing date of the final office action. Therefore, Applicant requests an advisory action or expeditious processing to issuance.

Respectfully submitted,

Kevin W. Bieg

Kevin W. Bieg
Attorney for Applicant
Reg. No. 40,912
Ph: 505 284-4784
Sandia National Laboratories
P.O. Box 5800/MS 0161
Albuquerque, NM 87185-01

CERTIFICATION UNDER 37 CFR 1.8

I hereby certify that this correspondence and documents referred to herein were deposited with the United States Postal Service as first class mail addressed to: Commissioner for Patents, Alexandria, VA 22313-1450 on the date shown below.

Date: 2-18-08

By: Mary Loukota